A REVIEW OF THE LITERATURE PERTAINING TO THE SOYBEAN CYST NEMATODE

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The soybean cyst nematode was first reported by Hori as a serious pest of soybeans in Japan in 1915, having been found in Shirakawa, Iwaki Province. Apparently the disease it causes was known previously to this time but the nematode was not recognized as the cause. Katsufuji named the disease "Yellow Dwarf" in 1919. These subsequent authors to 1952 mostly referred to the nematode as a "race" or "strain" of Heterodera schachtii, the sugar beet nematode, though a few authors, notably Filipjev and Schuurmans Stekhoven (1941), Goffart (1951) and Yokoo (1951) have identified it as a race of Heterodera göttingiana. In 1952 it was given the name which is now considered correct, Heterodera glycines, by Ichinohe.

H. glycines is one of three species of this genus which are parasites of various kinds of legumes. It is most closely related to the clover cyst nematode, H. trifolii (Goffart, 1932) Oostenbrink, 1949, but differs from it in several respects, as shown by Hirschmann (1956). As the name implies, the clover cyst nematode is a parasite of clovers, but also attacks other legumes including beans, Phaseolus vulgaris, according to Oostenbrink, (1951). The soybean cyst nematode is much less closely related to the pea cyst nematode, H. göttingiana Liebscher, 1892, which attacks various kinds of peas (Pisum arvense) and vetch (Vicia faba). The soybean cyst nematode can be differentiated from the pea cyst nematode by means of the empty cyst and from the clover cyst nematode or the sugar beet nematode if cysts with viable larvae are available for examination. The soybean cyst nematode is the only species of this genus known to attack soybeans.

History and distribution outside the United States

Subsequent to its being found in 1915, the soybean cyst nematode was reported from Niigata Prefecture by Ishikawa in 1916, from Hokkaido by Ito and by Tanaka from Ibaragi Prefecture in 1921. Ichinohe (1955b) gives a map which shows it to be distributed in a number of locations in the southern part of Hokkaido and states (1955a) that "The soybean nematode is widely distributed throughout Japan, particularly in Hokkaido, Tohuku, Hokuriku and Kanto districts. It was also recorded in Korea (Yokoo, 1936). Nakata and Asuyama (1938) surveyed and determined the distribution of this nematode in Manchuria."

There are no reports of the occurrence of this nematode in other parts of the world outside the United States, but it should be emphasized that information on the distribution of nematodes is fragmentary and incomplete at best.

Life History

The life history of the soybean cyst nematode has been reported by Ichinohe (1955a) as being in general similar to that of the sugar beet nematode. After an infected crop of soybeans has been grown, eggs of the nematode remain in the soil enclosed in cysts formed from the cuticle of the female body. These eggs hatch, and larvae emerge from them to make their way through the soil in search of plant roots on which they can feed. They are attracted to and enter the young roots of various kinds of legumes. Inside the root, they begin to feed and in host plants such as the soybean, grow rapidly in length and breadth, passing through several distinct life stages, the end of each of which is marked by a moult or shedding of the cuticle. There are four such moults, the first of which takes place in the egg before hatching. On the last moult, the adult stage is reached, and sexual organs are fully developed. At this time, the female is lemon-shaped and the male is long and slender. Length of the female is about 1/32nd of an inch and the male is about 1/16th of an inch long. The females remain attached to the roots, but have broken through to the surface and only

the neck remains inside the root. The male leaves the root. Females produce an average of about 400 eggs during their lifetime of several months. About half of these are deposited in the so-called "egg sac"; the remainder are retained in the female body. Eggs deposited in the egg sac hatch within a few days and the larvae move through the soil in search of new roots on which to feed. When the female finally dies, her body is transformed into a cyst which is highly resistant to decay. This encloses and protects the eggs which were not deposited. Larvae develop in these eggs to the infective stage, and some hatch in the cyst within a few weeks though many do not. Cysts remain in the soil after the soybeans have been harvested. Thus the soil at the end of the growing season will contain cysts with second stage larvae in eggs, and larvae which have hatched and left the egg sac or the cyst. According to Ichinohe, the generation time from egg to egg laying female is a minimum of 24 days at 74° F. and increases to 41 days at 64° F. Development took place as low as 50° F. In Hokkaido (northern Japan) there were a maximum of three generations per year. Larvae which hatch and fail to reach a plant on which they can feed remain in the second stage indefinitely, as do unhatched larvae.

Host Plants

Host plants are plants on which the soybean cyst nematode feeds and reproduces. If the host plant is what is known as a "suitable" one, such as soybean, development of the second stage larvae to the adult stage is rapid, normal males and females develop and an abundance of viable eggs is produced. According to Ichinohe (1953 and 1955a) only the soybean (Glycine max), the wild soybean (G. ussuriensis) and the Azuki bean (Phaseolus angularis) are suitable hosts of the soybean cyst nematode. On the kidney bean (P. vulgaris), development was slow, the females were abnormally small and egg production was only about one-fourth of that on soybean under similar conditions. Reproduction on the

Spanish runner or Multiflora bean (P. coccineus) was also very low. Larvae entered the roots of lima beans (P. lunatus), but did not develop to the adult stage or reproduce. Larvae also entered the roots of Ladino, Red, Crimson and Sweet Clover, garden peas, field peas, broad bean (Vicia faba), alfalfa and yellow lupine, but did not develop to maturity. There was little or no entry and no reproduction on corn, barley, wheat, oats, potato, tomato, red pepper, tobacco, cucumber, sugar beet, cabbage, flax, burdock, onion or carrot.

Studies by Skotland, Sasser and Winstead at North Carolina State College have shown that the soybean cyst nematode will reproduce on snap beans (Phaseolus vulgaris), on vetch and on annual lespedeza (Lespedeza stipulacea). It did not reproduce on 31 other kinds of common crop and ornamental plants tested.

It is evident that these tests have not been exhaustive. However, it has not been shown that the soybean cyst nematode will reproduce except on certain legumes. The legumes which it enters, but on which there is no reproduction, might serve as trap crops. These or other crops in which no reproduction takes place could be used in nematode reducing rotations.

The effect of the soybean cyst nematode on soybeans is seen in the field as a distinct yellowing and dwarfing of the plants. Heavily attacked plants produce few or no soybeans. A heavily infected crop in North Carolina produced only 4 bushels per acre. The effect on other hosts has not been reported.

Biology and Habits

An important fact about the soybean cyst nematode is that it is an obligate parasite, that is, it does not reproduce except on suitable host plants. Larvae are hatched with a reserve supply of food material. This is consumed at a rate depending on their activity, which in turn depends on soil temperature and moisture. When soil temperatures are high and moisture adequate, the larvae use up their reserves in a few months. Movements are slower in cold soil and the reserve food lasts longer. Unhatched larvae in eggs, being inactive, live

longer than hatched active larvae. Cold seems to have little or no effect on the larvae in the cysts. Ichinohe (1955a) reports that cysts exposed to temperatures as low as 40 degrees F below zero for 7 months still contained viable eggs.

Spread of the soybean cyst nematode by active movement of the larvae is probably very slow, amounting to not more than a few feet in a year. The cysts can be transported in many ways. They will be spread from place to place in a field or even from one field to another by means of cultivating implements, tractors, trucks and even in soil on the feet of men and animals. Machinery which moves from farm to farm, such as combines, can carry cysts for long distances. In experiments at North Carolina State College, only a fraction of one percent of larvae in cysts survived air drying for 6 weeks (Skotland, Sasser and Winstead, 1955).

Control

Control of the soybean cyst nematode in the field can be accomplished by crop rotation or by the use of chemicals.

Control by rotation is based on the fact that this nematode cannot feed or reproduce except on a suitable host plant. Lacking such a host plant, the larvae remaining in the soil after an infected crop has been grown must eventually die of starvation or be destroyed by parasites, diseases or other biological factors. Rotation is simply planting non-susceptible crops. No information on the rate of disappearance of these nematodes from a field is yet available. Judging from experience with the closely related sugar beet nematode, it seems probable that some larvae in cysts may remain viable for several years, though a major portion of the population will disappear in a year or two (Thorne, 1923). In practice the control of nematodes by rotation is hampered by the difficulty in keeping fields free of host plants. These may include weeds as well as volunteer plants of the susceptible crop.

Any other method of keeping the soil free of host plants will also be effective in control. Bare fallow would be effective, but is seldom practical. Fallow with weed growth would be effective only if none of the weeds were host plants.

Experiments with chemical control in North Carolina indicated that the soybean cyst nematode is no more difficult to control with methyl bromide, dichloropropene or dibromochloropropane fumigants than other cyst forming nematodes (Ende and Sasser, 1957). However, complete control was not obtained in any case, nor has complete control on a field scale been obtained with this or any other nematode by chemical means. Reduction of the nematode population by as much as 95% to 99% is comparatively easy. The largest amounts of dichloropropene fumigant used in the North Carolina experiments was 60 gallons per acre, which would cost about $90 per acre, including an allowance for application. The largest amount of dibromochloropropane used would cost about the same. The smallest amount of methyl bromide used would cost about $300 per acre, plus an estimated $200 for application, since the soil to be treated must be covered by a plastic tarpaulin.

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